Physics A: Conservation of Energy Example Problem

Scene #	Description	Narration
1	A diagram shows hills of a roller coaster. Four blue dots are on the path labeled point A, B, C and D. Point A is at the top of the first hill (this is also the tallest hill). Point B is at the bottom of the first hill. Point C is at the top of the smaller hill and Point D is at the end of the ride. The following measurements are lined up with each point. Point A: 54 m, Point B: 11 m, Point C: 26 m, Point D: 0 m. The narrator reads out loud the words on the slide.	Now let's look at a problem that allows us to apply the law of conservation of energy and see how energy is converted between different types. The diagram below shows the first two hills of a roller coaster. Assume the roller coaster cart has no velocity at point A. Now, you may want to copy down this diagram, as this is a four-part question. And we'll be referencing it throughout. The first part of the question asks, "what is the gravitational potential energy at point A-- 54 meters-- if the roller coaster cart has a mass of 1,490 kilograms?"
2	As the narrator solves part a, he writes down the steps to solving the problem as he says them out loud.	Let's begin by writing down the equation for gravitational potential energy. And that is gravitational potential energy is equal to an object's mass times the acceleration of gravity times the object's height above the ground. Fortunately, we know all of these values. So we can solve for gravitational potential energy. The cart's mass is 1,490 kilograms. The acceleration of gravity is 9.81 meters per second squared. We can leave off the minus sign because energy is always positive. And the cart's height above the ground at point A is 54 meters. Multiply all this out, and you'll find that the gravitational potential energy of the cart at point A is 789,000 joules.
3	As the narrator addresses question b, he writes in green the steps he says out loud to help answer the question.	Now let's look at the next part of the question. The next part asks, "assuming the roller coaster is nearly frictionless, what is the total energy of the roller coaster at points A, B, C, and D?" The important word to pay attention to here is "frictionless" because that tells us that total energy will be constant. And at point A, all of our energy was in the form of gravitational potential energy. And we had 789,000 joules of energy. And therefore, our total energy will always be 789,000 joules as long as there is no friction.

4	The narrator scrolls down to Part C. In blue he writes down the steps to solve this part of the problem, as he writes down each step he says them out loud.	Now let's look at the third part of this problem. Part C asks, "how fast is the roller coaster moving at point D, 0 meters?" Well, if the cart's height at point D is 0 meters, then we know that gravitational potential energy is equal to 0 joules. And all of our energy must be in the form of kinetic energy. So we can say kinetic energy must be equal to 789,000 joules. Kinetic energy is equal to 1/2 times an object's mass times its speed squared. So entering in our cart's mass, we get 789,000 joules is equal to 1/2 times 1,490 kilograms times speed squared. Simplifying that out, we get 789,000 joules is equal to 745 kilograms times speed squared. If we divide both sides of this equation by 745 kilograms, we get speed squared is equal to 1,059 meters squared per second squared. And if we take the square root of both sides of this equation, we get that speed is equal to 32.5 meters per second.
5	The narrator scrolls down to part d of the problem. In green he writes down the steps to solving the problem as he says the steps out loud.	Now let's look at the last part of the problem. The last part asks, "how fast is the roller coaster moving at point C"-- height of 26 meters-- "when it goes over the top of the second hill?" All right. We know our total energy is constant, so total energy still equals 789,000 joules. And that's going to be equal to a mixture of gravitational potential energy and kinetic energy. Substituting in the definitions of each of those, we get 789,000 joules is equal to mgh plus 1/2 mv squared. That's the definition of gravitational potential energy. And that's the definition of kinetic energy. Let's enter in the values that we know. And we get 789,000 joules is equal to the cart's mass-- 1,490 kilograms-- times gravity-- 9.81 meters per second squared-- times the object's height-- at this point, 26 meters-- plus 1/2 times the cart's mass-- again, 1,490 kilograms-- times

		speed squared. Simplifying this, you get 789,000 joules is equal to 380,000 joules plus 745 kilograms times speed squared. Subtract 380,000 joules from both sides of the equation, and you get 409,000 joules is equal to 745 kilograms times speed squared. Divide both sides of the equation by 745 kilograms, and you get speed squared is equal to 549 meters squared per second squared. Again, take the square root of both sides of this equation, and you'll find that the speed is equal to 23.4 meters per second.